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AD-A220 319

JUNE 1987 SC5441.QTR

(6) GROWTH OF TUNGSTEN BRONZE FAMILY CRYSTALS - L

QUARTERLY TECHNICAL REPORT NO. 4, 5, 6, 7

For Period 06/01/86 through 05/31/87

(5) 6|86 - 5|87 : 6|87

DARPA ORDER NO.:	4540
NAME OF CONTRACTOR:	(2) Rockwell International Corporation
EFFECTIVE DATE OF CONTRACT:	05/02/85
CONTRACT EXPIRATION DATE:	01/30/88
AMOUNT OF CONTRACT DOLLARS:	$1,245,307
CONTRACT NO.:	N0O014-85-C-2443
PRINCIPAL INVESTIGATOR:	Dr. R. R. Neurgaonkar (805) 373-4109
	Professor L. E. Cross Pennsylvania State University (814) 865-1181

This report covers [illegible] number(s) NONE

Technical Information

Extracted: Date: /

Initials

Sponsored By:

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DoD)
DARPA ORDER NO. 4540

(3) N00014-85-C-2443

A. OBJECTIVE

The objective of the present work is to develop suitable quality and size doped and undoped $Sr_{1-x}Ba_xNb_2O_6$ (SBN) single crystals or thin films that can be used in optical device studies. The second objective of this work is to develop a phenomenological model to explain the correlation between the ferroelectric and optical properties and thereby possibly control and optimize the material performance for device optical applications.

B. PROGRESS

The tungsten bronze $Sr_{1-x}Ba_xNb_2O_6$ solid solution, $0.75 \geq x \geq 0.25$, is important for various device applications, specifically photorefractive and electro-optic. Since the compositions $Sr_{0.75}Ba_{0.25}Nb_2O_6$ (SBN:75) and $Sr_{0.6}Ba_{0.4}Nb_2O_6$ (SBN:60) exhibit excellent transverse electro-optic properties, these compositions have been grown in optical quality. Recent developments in the crystal growth area indicate that the growth of optical quality Ce-doped SBN:75 and SBN:60 crystals is also possible, and crystals as large as 2 to 3 cm in diameter have been successfully grown. Both of these crystals exhibit excellent photorefractive properties; typical response time is 10 ms or better, and because of this fast response these crystals are making a significant

impact on various photorefractive applications such as optical computing, image processing and phase conjugation. Furthermore, it has recently been shown that the response of these crystals is sensitive to the Ce site preference in the tungsten bronze structure. For example, when Ce^{3+} was placed in the 12-fold coordinated site, the response was in the visible; whereas the response was extended to near IR when Ce^{3+} was placed in the 9-fold coordinated site. This is a unique advantage in the present work, and efforts are under way to identify another suitable dopant which will extend this response deeper into the IR region.

We have also successfully grown La^{3+}-doped SBN:60 single crystals for pyroelectric detector applications and they exhibit exceptionally large pyroelectric coefficients at room temperature. The addition of 1.5 mole% La^{3+} in SBN:60 lowers T_c to 35^{o} C, and for this addition the pyroelectric coefficient increases by nearly an order of magnitude. The quality of these crystals is excellent for detector applications.

We have successfully grown ferroelectric tungsten bronze $Sr_2KNb_5O_{15}$ thin films by the liquid phase epitaxial growth technique on (001), (100) and (110)-oriented SBN:60 substrates. Since the lattice

match between the film and substrate is very close, the quality of SKN films was found to be excellent in all growth directions, and films as thick as 5 to 25 μm have been grown. Dielectric and electro-mechanical coupling measurements show that the film quality and ferroelectric properties are sufficiently promising for surface acoustic wave and electro-optic device studies. Further efforts are underway to establish the electro-optic properties to determine the usefulness for optical wave guide applications. This successful establishment of this composition will open up a new avenue to develop other tungsten bronze compositions which are difficult to grow in the form of bulk single crystals. Since $Sr_2KNb_5O_{15}$ single crystals exhibit large electro-optic coefficient (r_{33} = 200 x 10^{-12} m/V), this composition is very important for various other electro-optic applications.

Efforts are also under way to investigate the optical applications for these films, specifically in Guided Wave Optics, and according to these results the necessary modifications in composition or growth conditions will be made.

C. MAJOR EQUIPMENT

None.

D. CHANGE IN PERSONNEL

None.

E. TRIPS AND VISITS

In February 1987, Dr. R. R. Neurgaonkar met Professor Amnon Yariv of Caltech and had discussions with him on future work.

In March 1987, Dr. R. R. Neurgaonkar met Drs. Dick Reynolds and John Neff of DARPA and gave a briefing on the current status of this program and outlined future work.

In March 1987, Professor L. E. Cross of Penn State University visited Rockwell for discussions on the DARPA contract and future work was planned.

F. PUBLICATIONS AND PRESENTATIONS

1. R. R. Neurgaonkar, W. K. Cory, J. R. Oliver, M. D. Ewbank and W. F. Hall, "Development and Modification of Photorefractive Properties in the Tungsten Bronze Family Crystals," Optical Engineering 26 (5), 392 (1987).

2. M. J. Miller, E. J. Sharp, G. L. Wood, W. W. Clark, G. J. Salamo and R. R. Neurgaonkar, "Time Response of Ce-Doped SBN:75 Self-Pumped Phase Conjugator," Opt. Lett. 12, 340 (1987).

3. G. A. Rakuljic, A. Yariv and R. R. Neurgaonkar, "Photorefractive Properties of Undoped and Cerium Doped Single Crystal SBN:60," Opt. Engineering 25 (11), 1212 (1986).

4. M. D. Ewbank, R. R. Neurgaonkar, W. K. Cory and J. Feinberg, "Photorefractive Properties of Strontium Barium Niobate," accepted for publication in Appl. Phys. Lett.

5. G. A. Rakuljic, K. Sayano, A. Yariv and R. R. Neurgaonkar, "Self-Starting Passive Phase Conjugate Mirror with Ce-Doped Strontium Barium Niobate," Appl. Phys. Lett. 50 (1), 10 (1987).

G. FUTURE WORK

Continue to establish the optimum cerium concentration in the 12- and 9-fold coordinated sites needed to improve the photorefractive response. The efforts will be extended to grow optical quality crystals of La^{3+}-doped SBN:60 or SBN:75 compositions for pyroelectric detector and optical applications. Continue to improve the LPE technique to include different types of bronze compositions.

H. FUNDING

Contract Estimated Cost	$1,155,549
Fixed Fee	$ 89,758
Total Estimated Contract Price	$1,245,307
Current Contract Funding	$1,245,307
Less Fee	$ 89,758
Available Cost	$1,155,549
Expenditure through 05/29/87 (Cost)	$ 404,313*
Balance of Available Funds (Cost)	$ 751,236

* Including $39,728 outstanding commitments